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Kuriyagawa et al.

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(54) **OUTBOARD MOTOR CONTROL APPARATUS**

(71) Applicant: **HONDA MOTOR CO., LTD.**, Minato-Ku, Tokyo (JP)

(72) Inventors: **Koji Kuriyagawa**, Wako (JP); **Hajime Yoshimura**, Wako (JP)

(73) Assignee: **Honda Motor Co., Ltd.**, Tokyo (JP)

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B63H 20/14 (2006.01)

(52) **U.S. Cl.**
CPC ***B63H 21/21*** (2013.01); ***B63H 20/14*** (2013.01); ***B63H 21/213*** (2013.01)

(58) **Field of Classification Search**
CPC . B63H 21/21; B63H 21/213; B63H 2021/216; B63H 20/14
USPC 440/1, 84, 86, 87
See application file for complete search history.

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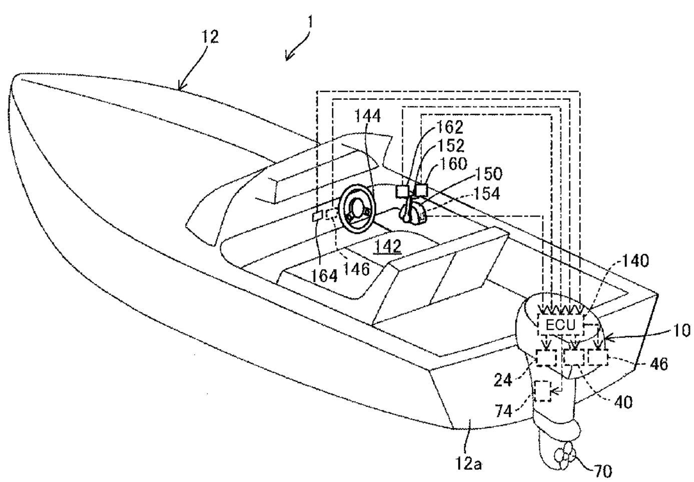
Primary Examiner — Ajay Vasudeva

(74) *Attorney, Agent, or Firm* — Carrier Blackman & Associates, P.C.; Joseph P. Carrier; William D. Blackman

(57) **ABSTRACT**

In an apparatus for controlling operation of an outboard motor having an internal combustion engine, a transmission and a low-speed cruise controller controlling a rotational speed of the propeller to make the boat cruise at low speed, the low-speed cruise controller outputs an increase/decrease command of the propeller rotational speed in response to an operator's manipulation, and change the gear position from the second speed to the first speed when the decrease command is outputted under a condition where the gear position is in the second speed and an engine speed is equal to or lower than a predetermined speed. With this, it becomes possible to decrease the propeller rotational speed to the maximum extent, thereby making a boat cruise at very low speed.

10 Claims, 12 Drawing Sheets



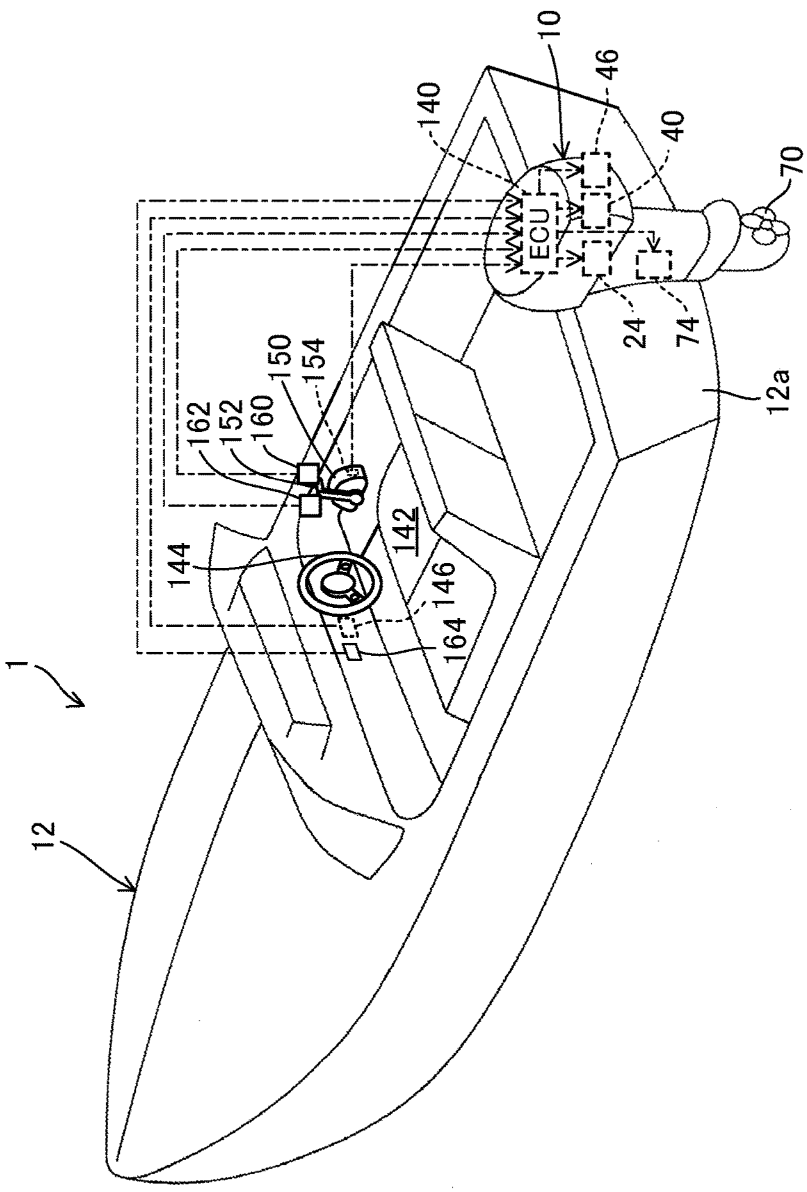

1
10
12
12a
24
40
46
70
74
140
142
144
146
150
152
154
160
162
164
ECU

FIG.1

FIG.2

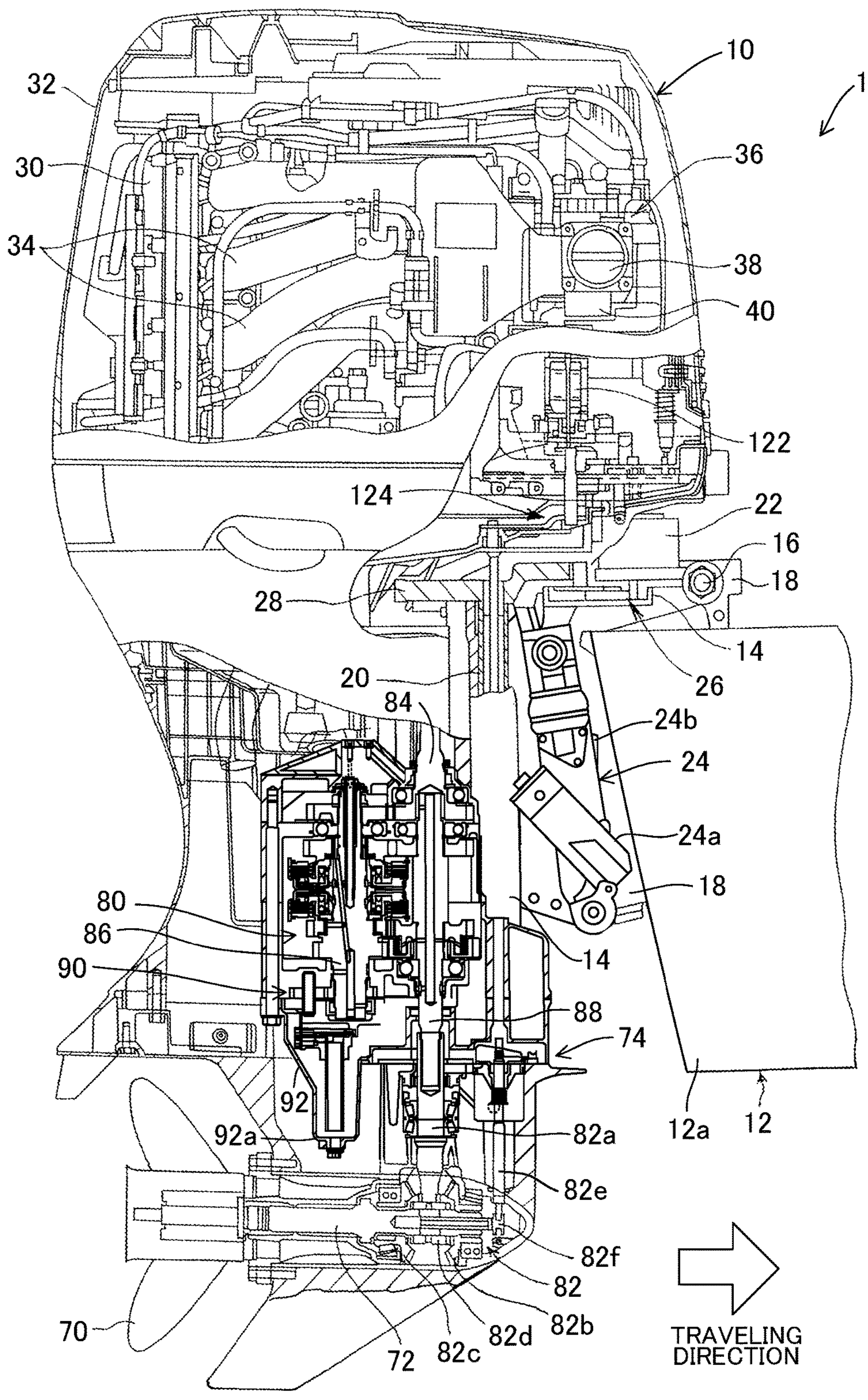

10
1
32
30
36
34
38
40
122
124
22
16
18
28
14
26
20
84
24b
24
24a
18
80
86
14
90
88
74
92
12a
12
92a
82a
82e
82f
82
70
82d
82b
72
82c
TRAVELING DIRECTION

FIG.3

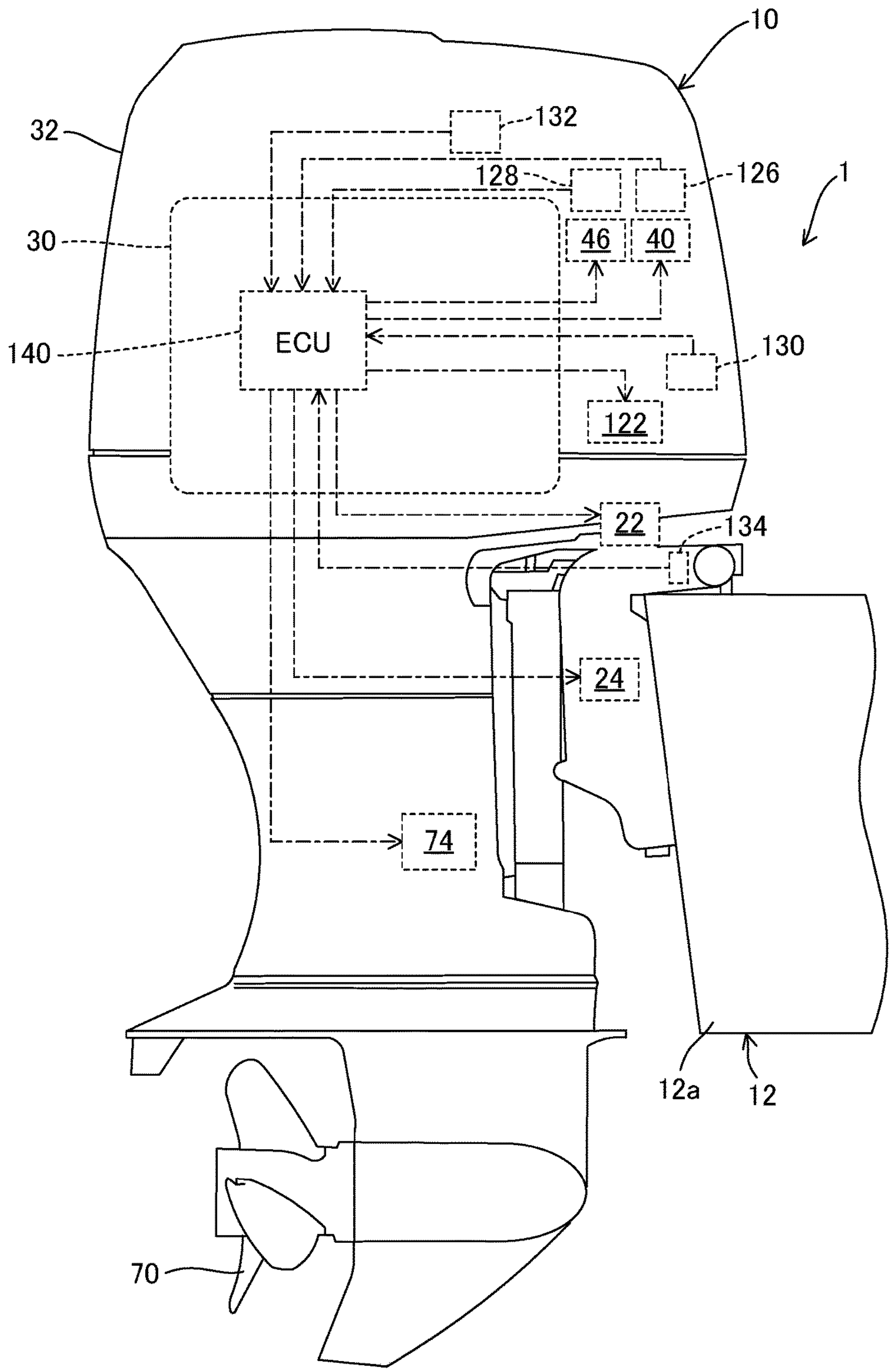


FIG.4

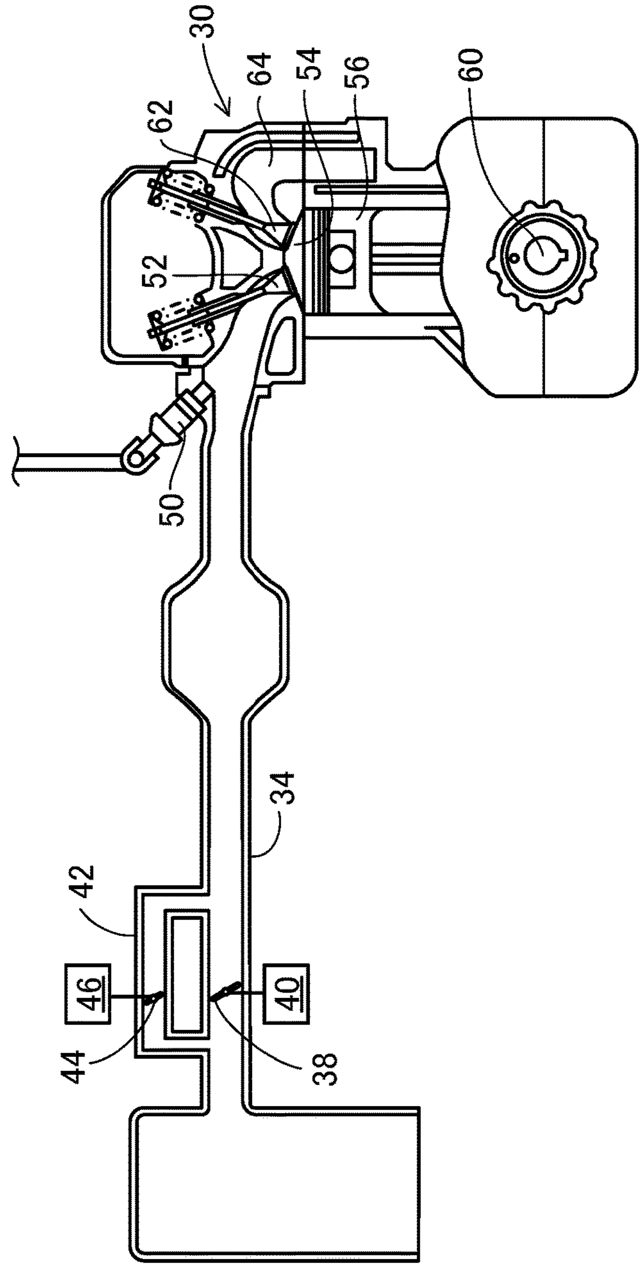


FIG.5

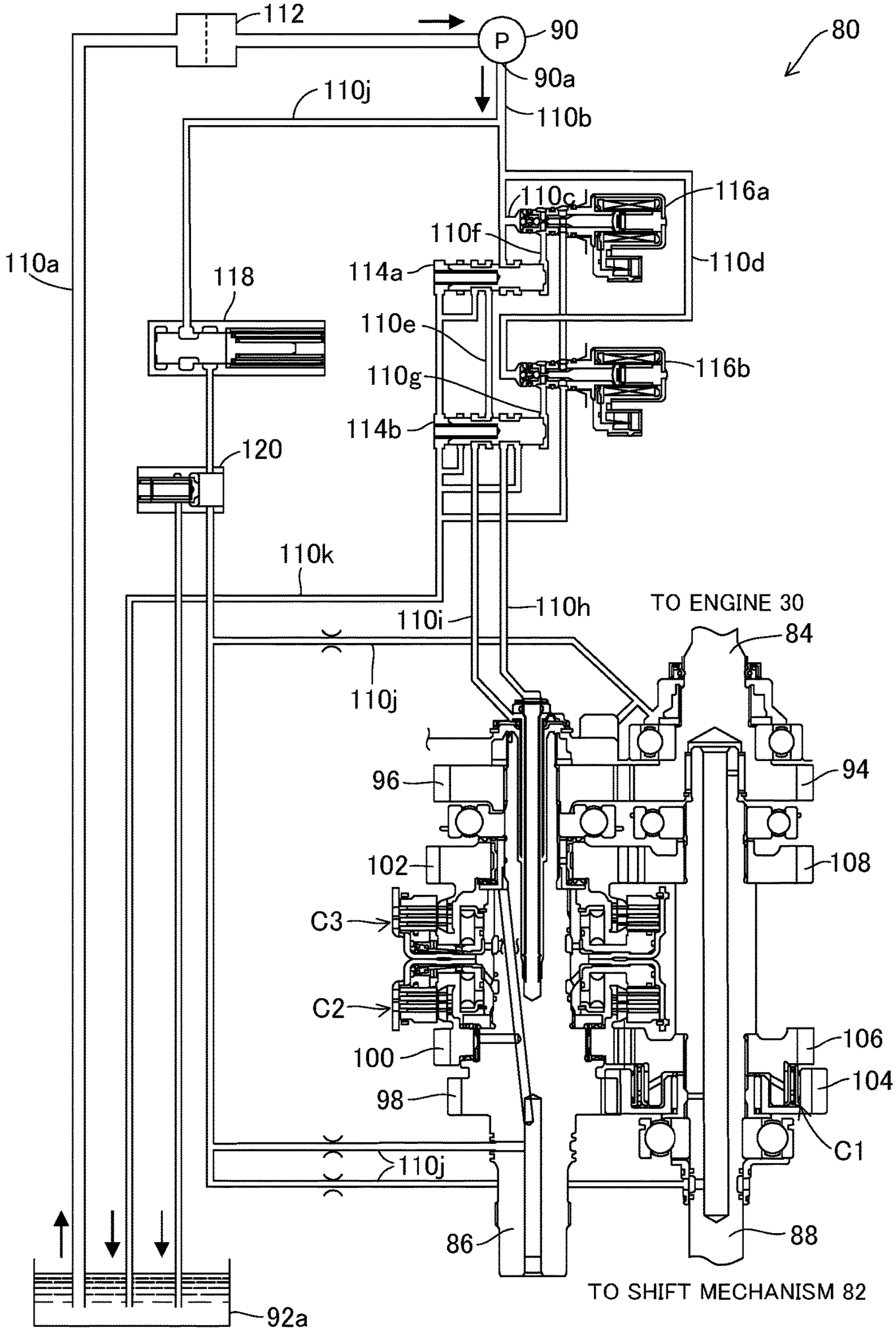

112
90
P
90a
80
110j
110b
110c
116a
110f
110d
110a
118
114a
110e
116b
110g
114b
120
110k
110i
110h
TO ENGINE 30
84
110j
96
94
102
108
C3
C2
106
100
104
98
C1
110j
86
88
TO SHIFT MECHANISM 82
92a

FIG.6

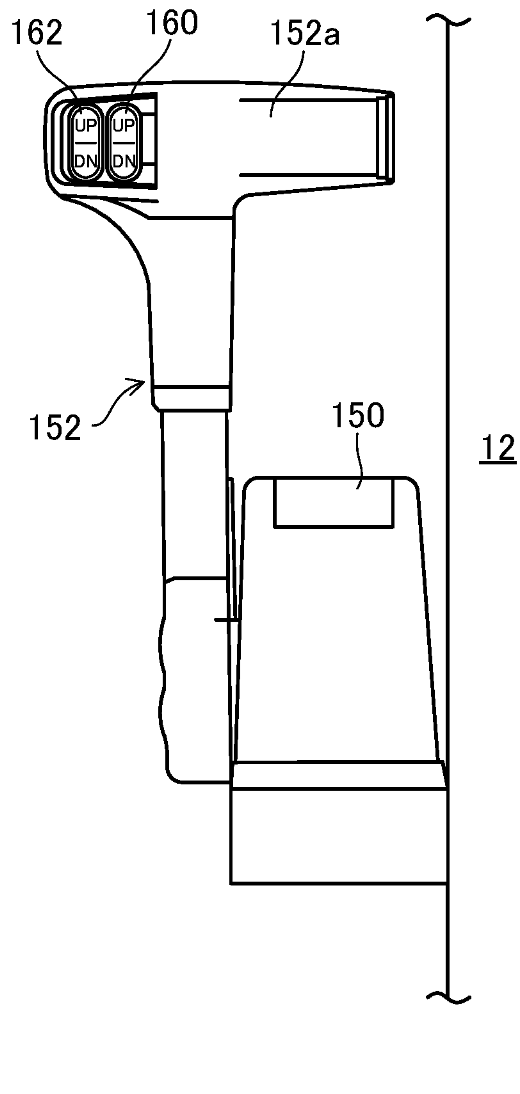


FIG. 7

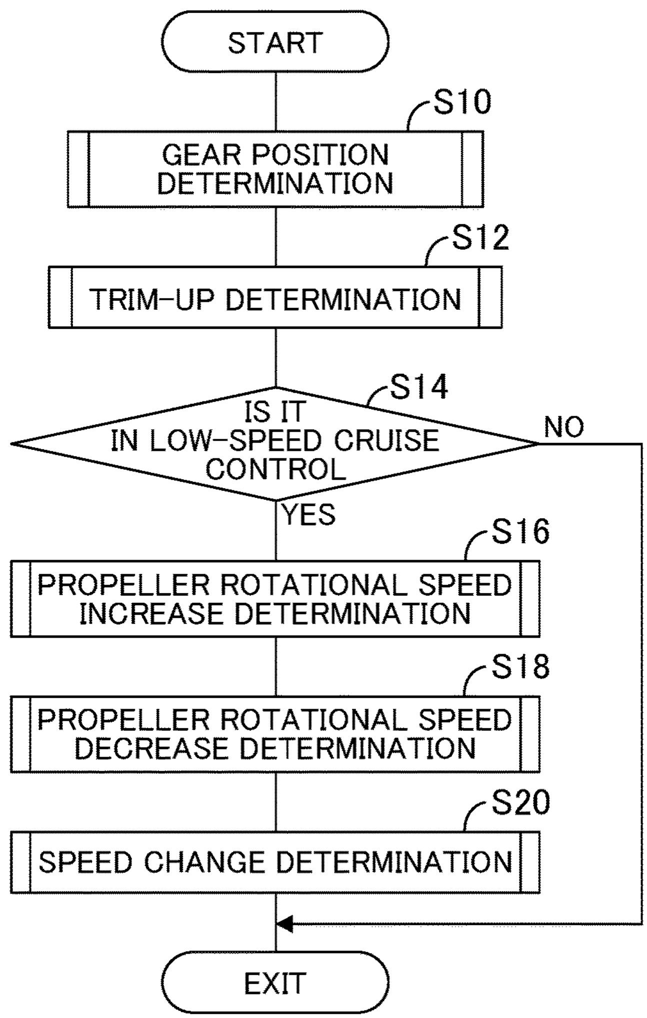

START
S10
GEAR POSITION DETERMINATION
S12
TRIM-UP DETERMINATION
S14
IS IT IN LOW-SPEED CRUISE CONTROL
NO
YES
S16
PROPELLER ROTATIONAL SPEED INCREASE DETERMINATION
S18
PROPELLER ROTATIONAL SPEED DECREASE DETERMINATION
S20
SPEED CHANGE DETERMINATION
EXIT

FIG.8

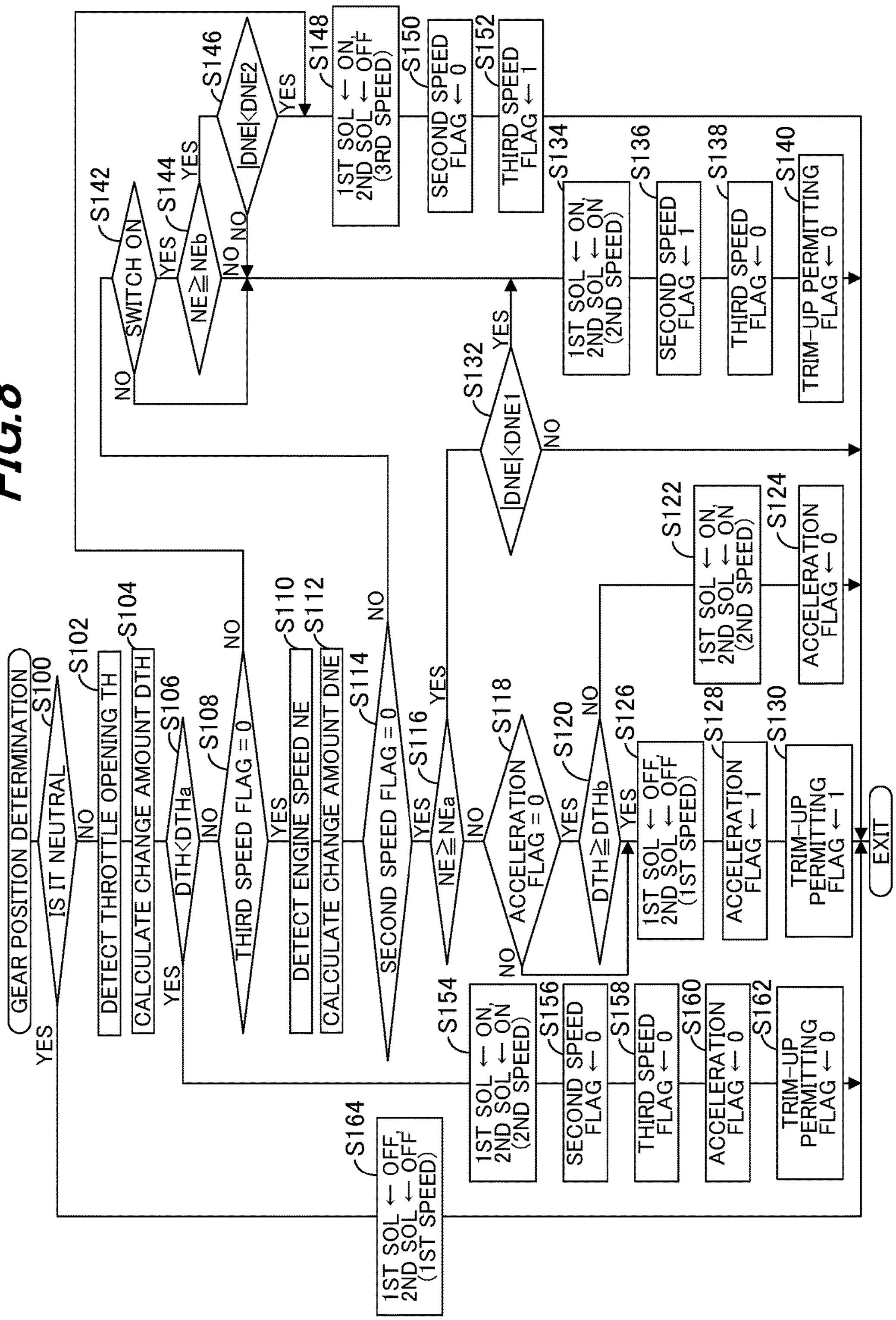

GEAR POSITION DETERMINATION
S100 IS IT NEUTRAL
YES
NO
S102 DETECT THROTTLE OPENING TH
S104 CALCULATE CHANGE AMOUNT DTH
S106 DTH<DTHa
S108 THIRD SPEED FLAG = 0
S110 DETECT ENGINE SPEED NE
S112 CALCULATE CHANGE AMOUNT DNE
S114 SECOND SPEED FLAG = 0
S116 NE≧NEa
S118 ACCELERATION FLAG = 0
S120 DTH≧DTHb
S122 1ST SOL ← ON, 2ND SOL ← ON (2ND SPEED)
S124 ACCELERATION FLAG ← 0
S126 1ST SOL ← OFF, 2ND SOL ← OFF (1ST SPEED)
S128 ACCELERATION FLAG ← 1
S130 TRIM-UP PERMITTING FLAG ← 1
S132 |DNE|<DNE1
S134 1ST SOL ← ON, 2ND SOL ← ON (2ND SPEED)
S136 SECOND SPEED FLAG ← 1
S138 THIRD SPEED FLAG ← 0
S140 TRIM-UP PERMITTING FLAG ← 0
S142 SWITCH ON
S144 NE≧NEb
S146 |DNE|<DNE2
S148 1ST SOL ← ON, 2ND SOL ← OFF (3RD SPEED)
S150 SECOND SPEED FLAG ← 0
S152 THIRD SPEED FLAG ← 1
S154 1ST SOL ← ON, 2ND SOL ← ON (2ND SPEED)
S156 SECOND SPEED FLAG ← 0
S158 THIRD SPEED FLAG ← 0
S160 ACCELERATION FLAG ← 0
S162 TRIM-UP PERMITTING FLAG ← 0
S164 1ST SOL ← OFF, 2ND SOL ← OFF (1ST SPEED)
EXIT

FIG.9

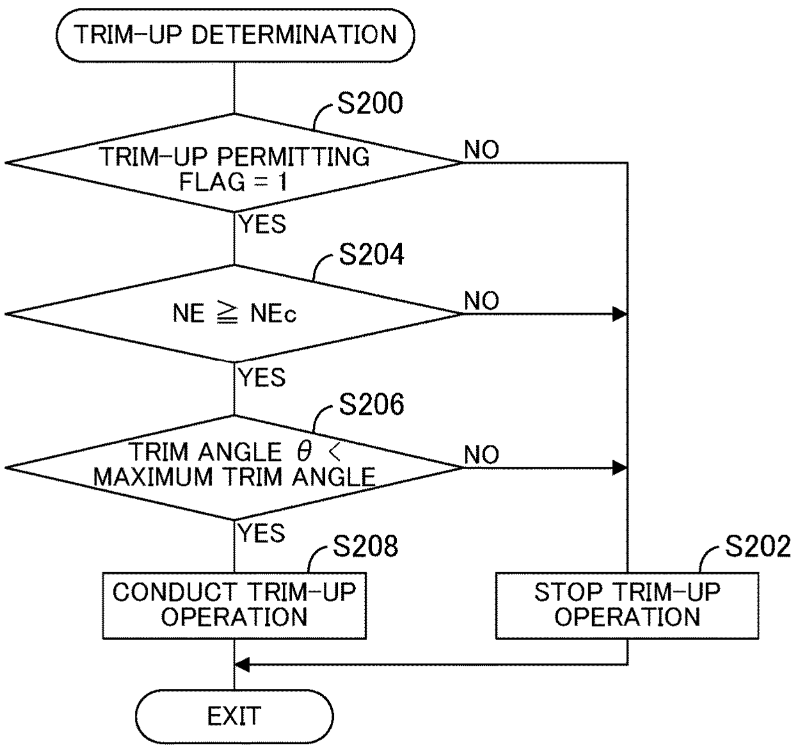

TRIM-UP DETERMINATION
S200
TRIM-UP PERMITTING FLAG = 1
NO
YES
S204
NE ≧ NEc
NO
YES
S206
TRIM ANGLE θ < MAXIMUM TRIM ANGLE
NO
YES
S208
CONDUCT TRIM-UP OPERATION
S202
STOP TRIM-UP OPERATION
EXIT

FIG. 10

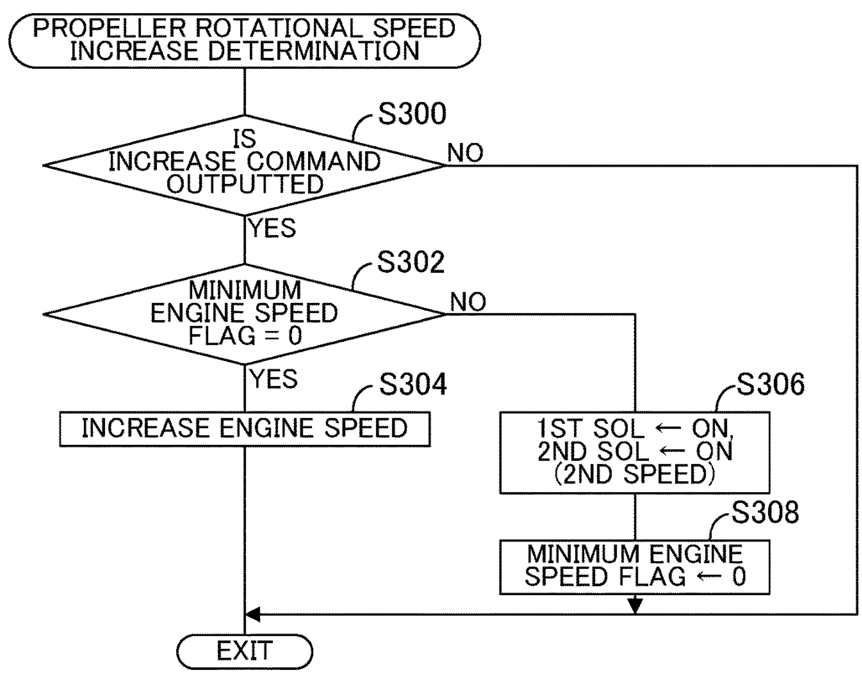

PROPELLER ROTATIONAL SPEED INCREASE DETERMINATION
S300
IS INCREASE COMMAND OUTPUTTED
NO
YES
S302
MINIMUM ENGINE SPEED FLAG = 0
NO
YES
S304
INCREASE ENGINE SPEED
S306
1ST SOL ← ON, 2ND SOL ← ON (2ND SPEED)
S308
MINIMUM ENGINE SPEED FLAG ← 0
EXIT

FIG. 11

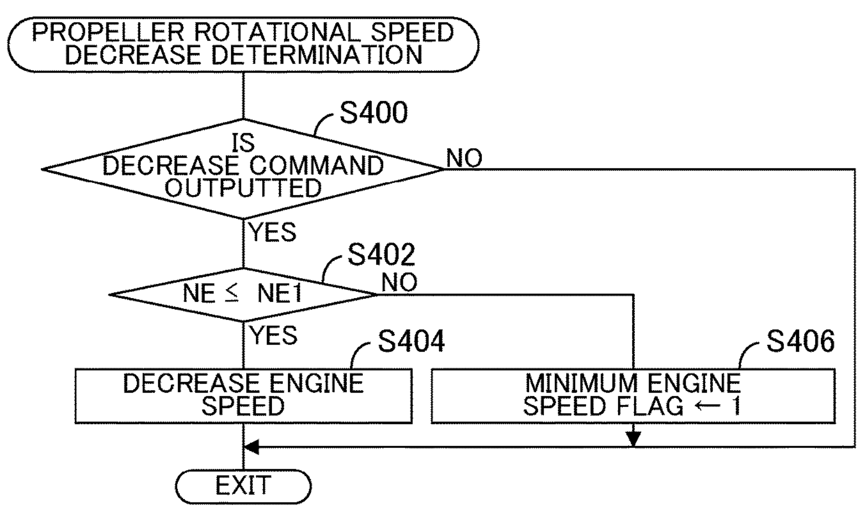

PROPELLER ROTATIONAL SPEED DECREASE DETERMINATION
S400
IS DECREASE COMMAND OUTPUTTED
NO
YES
S402
NE ≤ NE1
NO
YES
S404
DECREASE ENGINE SPEED
S406
MINIMUM ENGINE SPEED FLAG ← 1
EXIT

FIG. 12

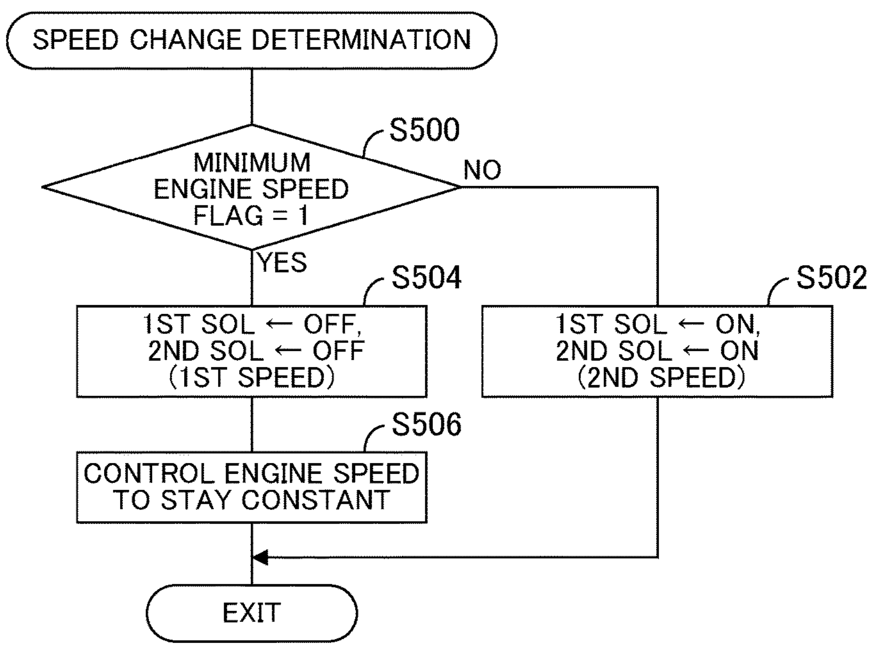
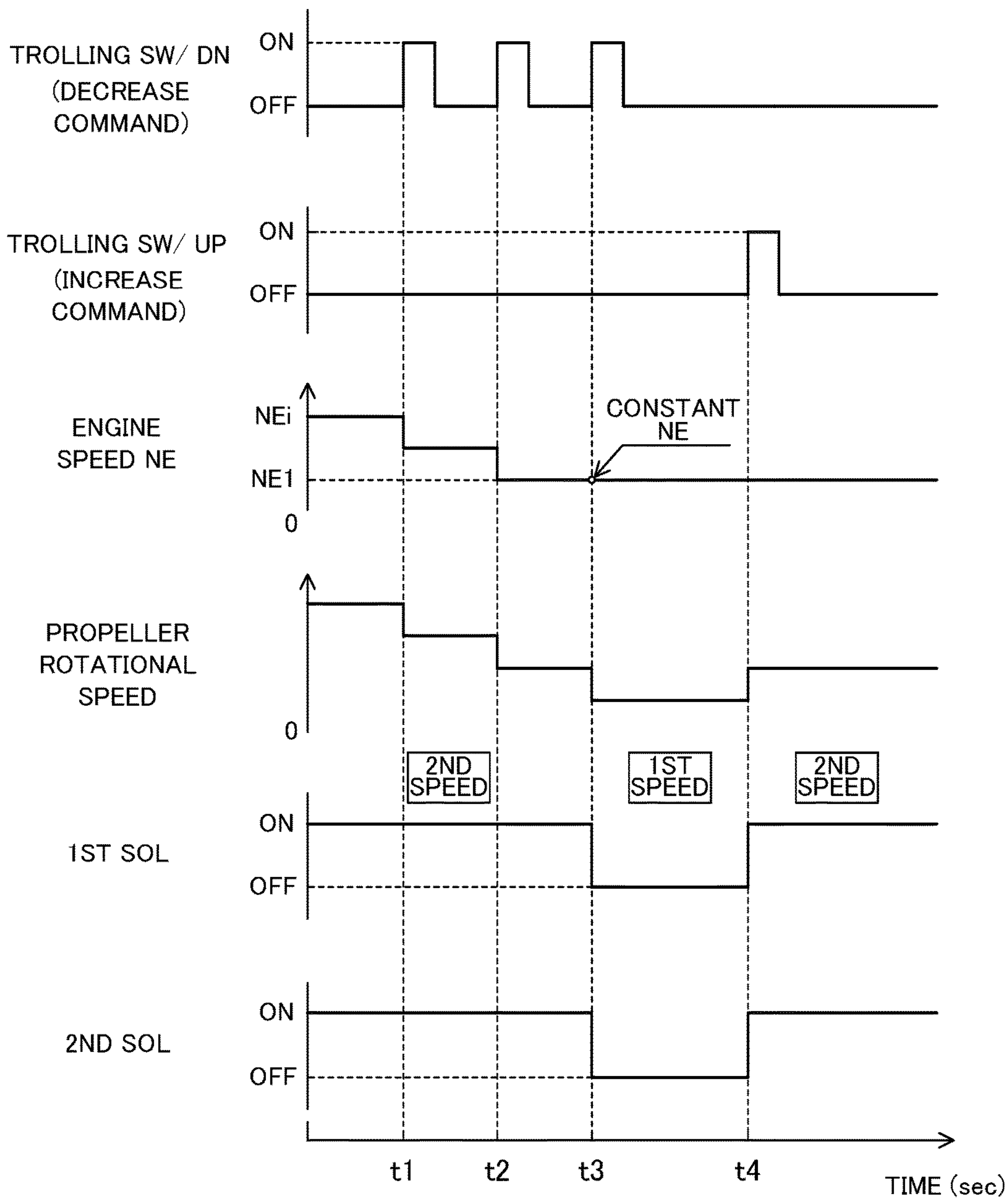

SPEED CHANGE DETERMINATION
S500
MINIMUM ENGINE SPEED FLAG = 1
NO
YES
S504
1ST SOL ← OFF, 2ND SOL ← OFF (1ST SPEED)
S502
1ST SOL ← ON, 2ND SOL ← ON (2ND SPEED)
S506
CONTROL ENGINE SPEED TO STAY CONSTANT
EXIT

FIG. 13



TROLLING SW/ DN
(DECREASE COMMAND)
ON
OFF
TROLLING SW/ UP
(INCREASE COMMAND)
ON
OFF
ENGINE SPEED NE
NEi
NE1
0
CONSTANT NE
PROPELLER ROTATIONAL SPEED
0
2ND SPEED
1ST SPEED
2ND SPEED
1ST SOL
ON
OFF
2ND SOL
ON
OFF
t1
t2
t3
t4
TIME (sec)

OUTBOARD MOTOR CONTROL APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/115,171, filed 25 May 2011, which claims priority under 35 USC §119 based on Japanese patent application No. 2010-123288, filed on May 28, 2010. The subject matter of these priority documents are incorporated by reference herein in their entirety.

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates to an outboard motor control apparatus, particularly to an apparatus for controlling an outboard motor with a transmission.

2. Background Art

In recent years, there is proposed a technique for an outboard motor having a transmission interposed at a power transmission shaft between an internal combustion engine and a propeller to change an output of the engine in speed and transmit it to the propeller, as taught, for example, by Japanese Laid-Open Patent Application No. 2009-202778. In the reference, an intake air amount is regulated to control a rotational speed of the propeller, thereby implementing low-speed cruise control (trolling control) for making a boat cruise at low speed.

SUMMARY OF INVENTION

In such the low-speed cruise control, it is sometimes preferred to further lower the boat speed by decreasing the rotational speed of the propeller and in this case, the intake air amount of the engine is decreased to decrease the rotational speed. However, since the engine has to avoid stalling, it is difficult to decrease the rotational speed through the regulation of the intake air amount.

An object of this invention is therefore to overcome the foregoing problem by providing an apparatus for controlling an outboard motor having a transmission, which apparatus can decrease a rotational speed of a propeller to the maximum extent, thereby making a boat cruise at very low speed.

In order to achieve the object, this invention provides in the first aspect an apparatus for controlling operation of an outboard motor adapted to be mounted on a stern of a boat and having an internal combustion engine to power a propeller through a drive shaft and a propeller shaft, a transmission that is installed at a location between the drive shaft and the propeller shaft, the transmission being selectively changeable in gear position to establish speeds including at least a first speed and a second speed and transmitting power of the engine to the propeller with a gear ratio determined by established speed, and a low-speed cruise controller adapted to control a rotational speed of the propeller to make the boat cruise at low speed, wherein the low-speed cruise controller includes: a propeller rotational speed increase/decrease command outputter adapted to output an increase command and decrease command of the rotational speed of the propeller in response to manipulation by the operator; and a first-speed changer adapted to change the gear position from the second speed to the first speed through the transmission when the decrease command is outputted under a condition where the gear position is in the second speed and a speed of the engine is equal to or lower than a predetermined speed.

In order to achieve the object, this invention provides in the second aspect a method for controlling operation of an outboard motor adapted to be mounted on a stern of a boat and having an internal combustion engine to power a propeller through a drive shaft and a propeller shaft, and a transmission that is installed at a location between the drive shaft and the propeller shaft, the transmission being selectively changeable in gear position to establish speeds including at least a first speed and a second speed and transmitting power of the engine to the propeller with a gear ratio determined by established speed, comprising the step of: controlling a rotational speed of the propeller to make the boat cruise at low speed, wherein the step of controlling includes the steps of: outputting an increase command and decrease command of the rotational speed of the propeller in response to manipulation by the operator; and changing the gear position from the second speed to the first speed through the transmission when the decrease command is outputted under a condition where the gear position is in the second speed and a speed of the engine is equal to or lower than a predetermined speed.

BRIEF DESCRIPTION OF DRAWINGS

The above and other objects and advantages of the invention will be more apparent from the following description and drawings in which:

FIG. **1** is an overall schematic view of an outboard motor control apparatus including a boat according to an embodiment of the invention;

FIG. **2** is an enlarged sectional side view partially showing the outboard motor shown in FIG. **1**;

FIG. **3** is an enlarged side view of the outboard motor shown in FIG. **1**;

FIG. **4** is a schematic view of an internal combustion engine shown in FIG. **2**, etc.;

FIG. **5** is a hydraulic circuit diagram schematically showing a hydraulic circuit of a transmission mechanism shown in FIG. **2**;

FIG. **6** is an enlarged side view of a remote control box and shift/throttle lever shown in FIG. **1** when viewed from the rear of the boat;

FIG. **7** is a flowchart showing transmission control operation, trim angle control operation and propeller rotational speed control operation by an electronic control unit shown in FIG. **1**;

FIG. **8** is a subroutine flowchart showing the operation of gear position determination in the FIG. **7** flowchart;

FIG. **9** is a subroutine flowchart showing the operation of trim-up determination in the FIG. **7** flowchart;

FIG. **10** is a subroutine flowchart showing the operation of propeller rotational speed increase determination in the FIG. **7** flowchart;

FIG. **11** is a subroutine flowchart showing the operation of propeller rotational speed decrease determination in the FIG. **7** flowchart;

FIG. **12** is a subroutine flowchart showing the operation of speed change determination in the FIG. **7** flowchart; and

FIG. **13** is a time chart for explaining the operation of the flowcharts of FIGS. **7** and **10** to **12**.

DESCRIPTION OF EMBODIMENT

An embodiment of an outboard motor control apparatus according to the invention will now be explained with reference to the attached drawings.

FIG. **1** is an overall schematic view of an outboard motor control apparatus including a boat according to an embodiment of the invention. FIG. **2** is an enlarged sectional side view partially showing the outboard motor shown in FIG. **1** and FIG. **3** is an enlarged side view of the outboard motor.

In FIGS. **1** to **3**, a symbol **1** indicates a boat or vessel whose hull **12** is mounted with the outboard motor **10**. As clearly shown in FIG. **2**, the outboard motor **10** is clamped (fastened) to the stern or transom **12***a* of the boat **1**, more precisely, to the stern **12***a* of the hull **12** through a swivel case **14**, tilting shaft **16** and stern brackets **18**.

An electric steering motor (actuator) **22** for operating a shaft **20** which is housed in the swivel case **14** to be rotatable about the vertical axis and a power tilt-trim unit (actuator; hereinafter called the "trim unit") **24** for regulating a tilt angle and trim angle of the outboard motor **10** relative to the boat **1** (i.e., hull **12**) by tilting up/down and trimming up/down are installed near the swivel case **14**. A rotational output of the steering motor **22** is transmitted to the shaft **20** via a speed reduction gear mechanism **26** and mount frame **28**, whereby the outboard motor **10** is steered about the shaft **20** as a steering axis to the right and left directions (steered about the vertical axis).

The trim unit **24** integrally comprises a hydraulic cylinder **24***a* for adjusting the tilt angle and a hydraulic cylinder **24***b* for adjusting the trim angle. In the trim unit **24**, the hydraulic cylinders **24***a*, **24***b* are extended/contracted so that the swivel case **14** is rotated about the tilting shaft **16** as a rotational axis, thereby tiling up/down and trimming up/down the outboard motor **10**. The hydraulic cylinders **24***a*, **24***b* are connected to a hydraulic circuit (not shown) in the outboard motor **10** and extended/contracted upon being supplied with operating oil therethrough.

An internal combustion engine (hereinafter referred to as the "engine") **30** is disposed in the upper portion of the outboard motor **10**. The engine **30** comprises a spark-ignition, water-cooling gasoline engine with a displacement of 2,200 cc. The engine **30** is located above the water surface and covered by an engine cover **32**.

An air intake pipe **34** of the engine **30** is connected to a throttle body **36**. The throttle body **36** has a throttle valve **38** installed therein and an electric throttle motor (actuator) **40** for opening and closing the throttle valve **38** is integrally disposed thereto.

The output shaft of the throttle motor **40** is connected to the throttle valve **38** via a speed reduction gear mechanism (not shown). The throttle motor **40** is operated to open and close the throttle valve **38**, thereby regulating the flow rate of the air sucked in the engine **30**.

FIG. **4** is a schematic view of the engine **30** shown in FIG. **2**, etc.

Explaining the engine **30** with reference to FIG. **4**, the air intake pipe **34** is connected with a bypass (secondary air passage) **42** that bypasses the throttle valve **38** by interconnecting the upstream and down stream sides of the throttle valve **38**. The bypass **42** is installed at the middle with a secondary air amount regulation valve **44** for regulating an intake air amount under the condition where the engine **30** is idling. The valve **44** is connected to an electric secondary air amount regulation motor (actuator) **46** via a speed reduction gear mechanism (not shown). When the motor **46** is operated, the valve **44** is opened and closed to regulate the amount of air flowing through the bypass **42**.

An injector **50** is installed near an air intake port downstream of the throttle valve **38** in the air intake pipe **34** for injecting gasoline fuel into the intake air regulated by the throttle valve **38** and secondary air amount regulation valve **44**. The injected fuel mixes with intake air to form an air-fuel mixture that flows into a combustion chamber **54** when an air intake valve **52** is opened.

The air-fuel mixture flown into the combustion chamber **54** is ignited by a spark plug (not shown) to burn, thereby driving a piston **56** downward in FIG. **4** to rotate a crankshaft **60**. When an exhaust valve **62** is opened, the exhaust gas produced by the combustion passes through an exhaust pipe **64** to be discharged outside the engine **30**.

Returning to the explanation on FIGS. **1** to **3**, the outboard motor **10** further comprises a propeller shaft (power transmission shaft) **72** that is supported to be rotatable about the horizontal axis and attached with a propeller **70** at its one end to transmit power output of the engine **30** thereto, and a transmission (automatic transmission) **74** that is interposed at a location between the engine **30** and propeller shaft **72** and has a plurality of gear positions, i.e., first, second and third speeds.

The transmission **74** comprises a transmission mechanism **80** that is selectively changeable in gear positions and a shift mechanism **82** that can change a shift position among forward, reverse and neutral positions.

FIG. **5** is a hydraulic circuit diagram schematically showing a hydraulic circuit of the transmission mechanism **80**.

As shown in FIGS. **2** and **5**, the transmission mechanism **80** comprises a parallel-axis type transmission mechanism with distinct gear positions (ratios), which includes an input shaft (drive shaft) **84** connected to the crankshaft (not shown in FIGS. **2** and **5**) of the engine **30**, a countershaft **86** connected to the input shaft **84** through a gear, and a first connecting shaft **88** connected to the countershaft **86** through several gears. Those shafts **84**, **86**, **88** are installed in parallel.

The countershaft **86** is connected with a hydraulic pump (gear pump; shown in FIGS. **2** and **5**) **90** that pumps up the operating oil (lubricating oil) and forwards it to transmission clutches and lubricated portions of the transmission mechanism **80** (explained later). The foregoing shafts **84**, **86**, **88**, hydraulic pump **90** and the like are housed in a case **92** (shown only in FIG. **2**). An oil pan **92***a* for receiving the operating oil is formed at the bottom of the case **92**.

In the so-configured transmission mechanism **80**, the gear installed on the shaft to be rotatable relative thereto is fixed on the shaft through the transmission clutch so that the transmission **74** is selectively changeable in the gear position to establish one of the three speeds (i.e., first to third speeds), and the output of the engine **30** is changed with the gear ratio determined by the established (selected) gear position (speed; gear) and transmitted to the propeller **70** through the shift mechanism **82** and propeller shaft **72**. A gear ratio of the gear position (speed) is set to be the highest in the first speed and decreases as the speed changes to second and then third speed.

The further explanation on the transmission mechanism **50** will be made. As clearly shown in FIG. **5**, the input shaft **84** is supported with an input primary gear **94**. The countershaft **86** is supported with a counter primary gear **96** to be meshed with the input primary gear **94**, and also supported with a counter first-speed gear **98**, counter second-speed gear **100** and counter third-speed gear **102**.

The first connecting shaft **88** is supported with an output first-speed gear **104** to be meshed with the counter first-speed gear **98**, an output second-speed gear **106** to be meshed with the counter second-speed gear **100**, and an output third-speed gear **108** to be meshed with the counter third-speed gear **102**.

In the above configuration, when the output first-speed gear **104** supported to be rotatable relative to the first connecting shaft **88** is brought into a connection with the first connecting shaft **88** through a first-speed clutch C**1**, the first speed (gear position) is established. The first-speed clutch C**1** comprises a one-way clutch. When a second-speed or third-speed hydraulic clutch C**2** or C**3** (explained later) is supplied with hydraulic pressure so that the second or third speed (gear position) is established and the rotational speed of the first connecting shaft **88** becomes greater than that of the output first-speed gear **104**, the first-speed clutch C**1** makes the output first-speed gear **104** rotate idly (i.e., rotate without being meshed).

When the counter second-speed gear **100** supported to be rotatable relative to the countershaft **86** is brought into a connection with the countershaft **86** through the second-speed hydraulic clutch (transmission clutch) C**2**, the second speed (gear position) is established. Further, when the counter third-speed gear **102** supported to be rotatable relative to the countershaft **86** is brought into a connection with the countershaft **86** through the third-speed hydraulic clutch (transmission clutch) C**3**, the third speed (gear position) is established. The hydraulic clutches C**2**, C**3** connect the gears **100**, **102** to the countershaft **86** upon being supplied with the hydraulic pressure, while making the gears **100**, **102** rotate idly when the hydraulic pressure is not supplied.

The interconnections between the gears and shafts through the clutches C**1**, C**2**, C**3** are performed by controlling the hydraulic pressure supplied from the pump **90** to the hydraulic clutches C**2**, C**3**.

The further explanation will be made. When the oil pump **90** is driven by the engine **30**, it pumps up the operating oil in the oil pan **92***a* to be drawn through an oil passage **110***a* and strainer **112** and forwards it from a discharge port **90***a* to a first switching valve **114***a* through an oil passage **110***b* and to first and second electromagnetic solenoid valves (linear solenoid valves) **116***a*, **116***b* through oil passages **110***c*, **110***d*.

The first switching valve **114***a* is connected to a second switching valve **114***b* through an oil passage **110***e*. Each of the valves **114***a*, **114***b* has a movable spool installed therein and the spool is urged by a spring at its one end (left end in the drawing) toward the other end. The valves **114***a*, **114***b* are connected on the sides of the other ends of the spools with the first and second solenoid valves **116***a*, **116***b* through oil passages **110***f*, **110***g*, respectively.

Upon being supplied with current (i.e., made ON), a spool housed in the first solenoid valve **116***a* is displaced to output the hydraulic pressure supplied from the pump **90** through the oil passage **110***c* to the other end side of the spool of the first switching valve **114***a*. Accordingly, the spool of the first switching valve **114***a* is displaced to its one end side, thereby forwarding the operating oil in the oil passage **110***b* to the oil passage **110***e*.

Similarly to the first solenoid valve **116***a*, upon being supplied with current (i.e., made ON), a spool of the second solenoid valve **116***b* is displaced to output the hydraulic pressure supplied from the pump **90** through the oil passage **110***d* to the other end side of the spool of the second switching valve **114***b*. Accordingly, the spool of the second switching valve **114***b* is displaced to its one end side, thereby forwarding the operating oil in the oil passage **110***e* to the second-speed hydraulic clutch C**2** through the oil passage **110***h*. In contrast, when the second solenoid valve **116***b* is not supplied with current (made OFF) and no hydraulic pressure is outputted to the other end side of the second switching valve **114***b*, the operating oil in the oil passage **110***e* is forwarded to the third-speed hydraulic clutch C**3** through the oil passage **110***i*.

When the first and second solenoid valves **116***a*, **116***b* are both made OFF, the hydraulic pressure is not supplied to the hydraulic clutches C**2**, C**3** and hence, the output first-speed gear **104** and first connecting shaft **88** are interconnected through the first-speed clutch C**1** so that the first speed is established.

When the first and second solenoid valves **116***a*, **116***b* are both made ON, the hydraulic pressure is supplied to the second-speed hydraulic clutch C**2** and accordingly, the counter second-speed gear **100** and countershaft **86** are interconnected so that the second speed is established. Further, when the first solenoid valve **116***a* is made ON and the second solenoid valve **116***b* is made OFF, the hydraulic pressure is supplied to the third-speed hydraulic clutch C**3** and accordingly, the counter third-speed gear **102** and countershaft **86** are interconnected so that the third speed is established.

Thus, one of the gear positions of the transmission **74** is selected (i.e., transmission control is conducted) by controlling ON/OFF of the first and second switching valves **114***a*, **114***b*.

Note that the operating oil (lubricating oil) from the hydraulic pump **90** is also supplied to the lubricated portions (e.g., the shafts **84**, **86**, **88**, etc.) of the transmission **74** through the oil passage **110***b*, an oil passage **110***j*, a regulator valve **118** and a relief valve **120**. Also, the first and second switching valves **114***a*, **114***b* and the first and second solenoid valves **116***a*, **116***b* are connected with an oil passage **110***k* adapted to relieve pressure.

The explanation on FIG. **2** is resumed. The shift mechanism **82** comprises a second connecting shaft **82***a* that is connected to the first connecting shaft **88** of the transmission mechanism **80** and installed parallel to the vertical axis to be rotatably supported, a forward bevel gear **82***b* and reverse bevel gear **82***c* that are connected to the second connecting shaft **82***a* to be rotated, a clutch **82***d* that can engage the propeller shaft **72** with either one of the forward bevel gear **82***b* and reverse bevel gear **82***c*, and other components.

The interior of the engine cover **32** is disposed with an electric shift motor (actuator) **122** that drives the shift mechanism **82**. The output shaft of the shift motor **122** can be connected via a speed reduction gear mechanism **124** with the upper end of a shift rod **82***e* of the shift mechanism **82**. When the shift motor **122** is operated, its output appropriately displaces the shift rod **82***e* and a shift slider **82***f* to move the clutch **82***d* to change the shift position among forward, reverse and neutral positions.

When the shift position is the forward or reverse position, the rotational output of the first connecting shaft **88** is transmitted via the shift mechanism **82** to the propeller shaft **72** to rotate the propeller **70** to generate the thrust in one of the directions making the boat **1** move forward or backward. The outboard motor **10** is equipped with a power source (not shown) such as a battery or the like attached to the engine **30** to supply operating power to the motors **22**, **40**, **46**, **122**, etc.

As shown in FIG. **3**, a throttle opening sensor **126** is installed near the throttle valve **38** and produces an output or signal indicative of opening of the throttle valve **38**, i.e., throttle opening TH, while another throttle opening sensor **128** is installed near the secondary air amount regulation valve **44** and produces an output or signal indicative of opening TH**2** of the valve **44**.

A neutral switch **130** is installed near the shift rod **82***e* and produces an ON signal when the shift position of the transmission **74** is neutral and an OFF signal when it is forward or reverse. A crank angle sensor **132** is installed near the crankshaft of the engine **30** and produces a pulse signal at every predetermined crank angle.

A trim angle sensor (i.e., a rotation angle sensor such as a rotary encoder) **134** is installed near the tilting shaft **16** and produces an output or signal corresponding to a trim angle θ of the outboard motor **10** (i.e., a rotation angle of the outboard motor **10** about its pitching axis relative to the hull **12**).

The outputs of the foregoing sensors and switch are sent to an Electronic Control Unit (ECU) **140** disposed in the outboard motor **10**. The ECU **140** which has a microcomputer comprising a CPU, ROM, RAM and other devices is installed in the engine cover **32** of the outboard motor **10**.

As shown in FIG. **1**, a steering wheel **144** is installed near a cockpit (the operator's seat) **142** of the hull **12** to be manipulated or rotated by the operator (not shown). A steering angle sensor **146** attached on a shaft (not shown) of the steering wheel **144** produces an output or signal corresponding to the steering angle applied or inputted by the operator through the steering wheel **144**.

A remote control box **150** provided near the cockpit **142** is equipped with a shift/throttle lever (throttle lever) **152** installed to be manipulated by the operator. The lever **152** can be moved or swung in the front-back direction from the initial position and is used by the operator to input a forward/reverse change command and an engine speed regulation command (i.e., a desired engine speed NEd) including an acceleration/deceleration command or instruction for the engine **30**. A lever position sensor **154** is installed in the remote control box **150** and produces an output or signal corresponding to a position of the lever **152**.

FIG. **6** is an enlarged side view of the remote control box **150** and lever **152** shown in FIG. **1** when viewed from the rear of the boat.

The lever **152** is equipped with a grip **152***a* to be gripped or held by the operator and the grip **152***a* is provided with a power tilt-trim switch (hereinafter called the "trim switch") **160** and trolling switch (switch; propeller rotational speed increase/decrease command outputter) **162**. The switches **160**, **162** are installed to be manually operated by the operator.

The trim switch **160** comprises pushing type switches including an up switch ("UP" in FIG. **6**) and a down switch ("DN"). When the up switch is pressed by the operator, the trim switch **160** produces an output or signal indicative of a tilt-up/trim-up command, while when the down switch is pressed, producing an output or signal indicative of a tilt-down/trim-down command.

Similarly, the trolling switch **162** comprises pushing type switches including an up switch ("UP" in FIG. **6**) and a down switch ("DN") and produces an output or signal (ON signal) indicative of a command to make the rotational speed of the propeller **70** increase when the up switch is pressed, while producing that (ON signal) indicative of a command to make the rotational speed of the propeller **70** decrease when the down switch is pressed. Thus the trolling switch **162** outputs a propeller rotational speed increase/decrease command in response to the manipulation by the operator.

As shown in FIG. **1**, a switch **164** is also provided near the cockpit **142** to be manually operated by the operator to input a fuel consumption decreasing command for decreasing fuel consumption of the engine **30**. The switch **164** is manipulated or pressed when the operator desires to travel the boat **1** with high fuel efficiency, and upon the manipulation, it produces a signal (ON signal) indicative of the fuel consumption decreasing command. The outputs of the sensors **146**, **154** and switches **160**, **162**, **164** are also sent to the ECU **140**.

Based on the inputted outputs, the ECU **140** controls the operation of the motors **22**, **122**, while performing the transmission control of the transmission **74** and the trim angle control for regulating the trim angle θ through the trim unit **24**.

The ECU **140** also detects or calculates a speed of the engine **30**, i.e., engine speed NE by counting the output pulses from the crank angle sensor **102** and based on the detected engine speed NE and throttle opening TH, controls the operation of the throttle motor **40** and secondary air amount regulation motor **46** so that the engine speed NE is converged to the desired engine speed NEd (precisely, the desired engine speed NEd set based on the lever **152** position and the signal from the trolling switch **162**; explained later), thereby regulating the intake air amount of the engine **30** to perform propeller rotational speed control for controlling the rotational speed of the propeller **70**.

Thus, the outboard motor control apparatus according to the embodiment is a Drive-By-Wire type apparatus whose operation system (steering wheel **144**, lever **152**) has no mechanical connection with the outboard motor **10**.

FIG. **7** is a flowchart showing transmission control operation, trim angle control operation and propeller rotational speed control operation by the ECU **140**. The illustrated program is executed by the ECU **140** at predetermined intervals, e.g., 100 milliseconds.

The program begins at S**10**, in which the operation for determining which one from among the first to third speeds of the transmission **74** should be selected, is conducted.

FIG. **8** is a subroutine flowchart showing the operation of the gear position determination. First, in S**100**, it is determined whether the shift position of the transmission **74** is at the neutral position. This determination is made by checking as to whether the neutral switch **130** outputs the ON signal. When the result in S**100** is negative, i.e., it is determined to be in gear, the program proceeds to S**102**, in which the throttle opening TH is detected or calculated from the output of the throttle opening sensor **126**, and to S**104**, in which a change amount (variation) DTH of the detected throttle opening TH per unit time (e.g., 500 milliseconds) is detected or calculated.

The program proceeds to S**106**, in which it is determined whether the deceleration is instructed to the engine **30** by the operator, i.e., whether the engine **30** is in the operating condition to decelerate the boat **1**. This determination is made by checking as to whether the throttle valve **38** is operated in the closing direction. More specifically, when the change amount DTH is less than a deceleration-determining predetermined value DTHa (e.g., −0.5 degree) set to a negative value, the throttle valve **38** is determined to be operated in the closing direction (i.e., the deceleration is instructed to the engine **30**).

When the result in S**106** is negative, the program proceeds to S**108**, in which it is determined whether the bit of an after-acceleration third-speed changed flag (explained later; hereinafter called the "third speed flag") which indicates that the gear position has been changed to the third speed after the acceleration was completed, is 0. Since the initial value of this flag is 0, the result in S**108** in the first program loop is generally affirmative and the program proceeds to S**110**.

The program proceeds to S**110**, in which the engine speed NE is detected or calculated from the output of the crank angle sensor **132** and to S**112**, in which a change amount (variation) DNE of the engine speed NE is calculated. The change amount DNE is obtained by subtracting the engine speed NE detected in the present program loop from that detected in the previous program loop.

Next, the program proceeds to S**114**, in which it is determined whether the bit of an after-acceleration second-speed changed flag (hereinafter called the "second speed flag") is 0. The bit of this flag is set to 1 when the gear position is changed from the first speed to the second speed after the acceleration is completed, and otherwise, reset to 0.

Since the initial value of the second speed flag is also 0, the result in S**114** in the first program loop is generally affirmative and the program proceeds to S**116**, in which it is determined whether the engine speed NE is equal to or greater than a second-speed change prescribed speed NEa. The prescribed speed NEa will be explained later.

Since the engine speed NE is generally less than the prescribed speed NEa in a program loop immediately after the engine start, the result in S**116** is negative and the program proceeds to S**118**, in which it is determined whether the bit of an acceleration determining flag (explained later; indicated by "acceleration flag" in the drawing) is 0. Since the initial value of this flag is also 0, the result in S**118** in the first program loop is generally affirmative and the program proceeds to S**120**.

In S**120**, it is determined whether the acceleration (precisely, the rapid acceleration) is instructed to the engine **30** by the operator, i.e., whether the engine **30** is in the operating condition to (rapidly) accelerate the boat **1**. This determination is made by checking as to whether the throttle valve **38** is operated in the opening direction rapidly.

Specifically, the change amount DTH of the throttle opening TH detected in S**104** is compared with an acceleration-determining predetermined value DTHb and when the change amount DTH is equal to or greater than the predetermined value DTHb, it is determined that the throttle valve **38** is operated in the opening direction rapidly, i.e., the acceleration is instructed to the engine **30**. The predetermined value DTHb is set to a value (positive value, e.g., 0.5 degree) greater than the deceleration-determining predetermined value DTHa, as a criterion for determining whether the acceleration is instructed to the engine **30**.

When the result in S**120** is negative, i.e., it is determined that neither the acceleration nor the deceleration is instructed to the engine **30**, the program proceeds to S**122**, in which the first and second solenoid valves **116***a*, **116***b* (indicated by "1ST SOL," "2ND SOL" in the drawing) are both made ON to select the second speed in the transmission **74**, and to S**124**, in which the bit of the acceleration determining flag is reset to 0.

On the other hand, when the result in S**120** is affirmative, the program proceeds to S**126**, in which the first and second solenoid valves **116***a*, **116***b* are both made OFF to change the gear position (shift down the gear) of the transmission **74** from the second speed to the first speed. As a result, the output torque of the engine **30** is amplified through the transmission **74** (more precisely, the transmission mechanism **80**) which has been shifted down to the first speed, and transmitted to the propeller **70** via the propeller shaft **72**, thereby improving the acceleration performance.

Then the program proceeds to S**128**, in which the bit of the acceleration determining flag is set to 1. Specifically, the bit of this flag is set to 1 when the change amount DTH of the throttle opening TH is equal to or greater than the acceleration-determining predetermined value DTHb and the transmission **74** is changed from the second speed to the first speed, and otherwise, reset to 0. Upon setting of the bit of the acceleration determining flag to 1, the result in S**118** in the next and subsequent loops becomes negative and the program skips S**120**.

Thus, since the transmission **74** is set in the second speed during a period from when the engine **30** is started until the acceleration is instructed (i.e., during the normal operation), it becomes possible to ensure the usability of the outboard motor **10** similarly to that of an outboard motor having no transmission.

Next, the program proceeds to S**130**, in which the bit of a trim-up permitting flag (initial value 0) is set to 1, whereafter the program is terminated. Specifically, the bit of this flag being set to 1 means that the change amount DTH is equal to or greater than the predetermined value DTHb and the transmission **74** is changed to the first speed, in other words, the trim-up operation to be conducted based on the engine speed NE is permitted (explained later), while that being reset to 0 means that the trim-up operation is not needed, i.e., for example, the deceleration is instructed to the engine **30**.

After the transmission **74** is changed to the first speed, when the engine speed NE is gradually increased and the acceleration through the torque amplification in the first speed is completed (i.e., the acceleration range is saturated), the engine speed NE reaches the prescribed speed NEa. Consequently, in the following program loop, the result in S**116** becomes affirmative and the program proceeds to S**132** onward. The prescribed speed NEa is set to a relatively high value (e.g., 6000 rpm) as a criterion for determining whether the acceleration in the first speed is completed.

In S**132**, it is determined whether the engine speed NE is stable, i.e., the engine **30** is stably operated. This determination is made by comparing an absolute value of the change amount DNE of the engine speed NE with a first prescribed value DNE**1**. When the absolute value is less than the first prescribed value DNE**1**, the engine speed NE is determined to be stable. The first prescribed value DNE**1** is set as a criterion (e.g., 500 rpm) for determining whether the engine speed NE is stable, i.e., the change amount DNE is relatively small.

When the result in S**132** is negative, the program is terminated with the first speed being maintained, and when the result is affirmative, the program proceeds to S**134**, in which the first and second solenoid valves **116***a*, **116***b* are both made ON to change the transmission **74** (shift up the gear) from the first speed to the second speed. It causes the increase in the rotational speed of the shaft **82***a* and that of the propeller shaft **72**, so that the boat speed reaches the maximum speed (in a range of the engine performance), thereby improving the speed performance.

Then the program proceeds to S**136**, in which the bit of the second speed flag is set to 1, to S**138**, in which the bit of the third speed flag is reset to 0 and to S**140**, in which the bit of the trim-up permitting flag is reset to 0. As a result, the trim-up operation of the outboard motor **10** is stopped in another program (explained later) at the same time (synchronously) when the gear position is changed from the first speed to the second speed.

When the bit of the second speed flag is set to 1 in S**136**, the result in S**114** in the next and subsequent program loops becomes negative and the program proceeds to S**142**. Thus the process of S**142** onward is conducted when the bit of the second speed flag is set to 1, i.e., the gear position is changed to the second speed after the acceleration in the first speed is completed.

In S**142**, it is determined whether the switch **164** outputs the ON signal, i.e., whether the fuel consumption decreasing command for the engine **30** is inputted by the operator. When the result in S**142** is negative, the program proceeds to S**134** to S**140** mentioned above, while when the result is affirmative, proceeding to S**144**, in which it is determined whether the engine speed NE is equal to or greater than a third-speed change prescribed speed NEb. The prescribed speed NEb is set to a value (e.g., 5000 rpm) slightly lower than the second-speed change prescribed speed NEa, as a criterion for determining whether it is possible to change the gear position to the third speed (explained later).

When the result in S**144** is affirmative, the program proceeds to S**146**, in which, similarly to S**132**, it is determined whether the engine speed NE is stable. Specifically, the absolute value of the change amount DNE of the engine speed NE is compared with a second prescribed value DNE**2** and when it is less than the second prescribed value DNE**2**, the engine speed NE is determined to be stable. The second prescribed value DNE**2** is set as a criterion (e.g., 500 rpm) for determining whether the change amount DNE is relatively small and the engine speed NE is stable.

When the result in S**146** or S**144** is negative, the program proceeds to S**134** and when the result in S**146** is affirmative, the program proceeds to S**148**, in which the first solenoid valve **116***a* is made ON and the second solenoid valve **116***b* is made OFF to change the transmission **74** (shift up the gear) from the second speed to the third speed. As a result, the engine speed NE is decreased, thereby decreasing the fuel consumption, i.e., improving the fuel efficiency.

Next, the program proceeds to S**150**, in which the bit of the second speed flag is reset to 0 and to S**152**, in which the bit of the third speed flag is set to 1. Thus, the third speed flag is set to 1 when the gear position is changed from the second speed to the third speed after the acceleration is completed, and otherwise, reset to 0. Note that, in a program loop after the bit of the third speed flag is set to 1, the result in S**108** is negative and the process of S**148** to S**152** is conducted, whereafter the program is terminated with the third speed being maintained.

When the result in S**106** is affirmative, the program proceeds to S**154**, in which the first and second solenoid valves **116***a*, **116***b* are both made ON to change the gear position to the second speed. Then the program proceeds to S**156**, S**158**, S**160** and S**162**, in which the bits of the second speed flag, third speed flag, acceleration determining flag and trim-up permitting flag are all reset to 0.

When the lever **152** is manipulated by the operator to change the shift position of the transmission **74** to neutral, the result in S**100** is affirmative and the program proceeds to S**164**, in which the first and second solenoid valves **116***a*, **116***b* are both made OFF to change the transmission **74** from the second speed to the first speed.

Returning to the explanation on the FIG. **7** flowchart, the program proceeds to S**12**, in which it is determined whether the trim-up operation of the outboard motor **10** should be conducted.

FIG. **9** is a subroutine flowchart showing the operation of the trim-up determination. As shown in FIG. **9**, in S**200**, it is determined whether the bit of the trim-up permitting flag is 1. When the result in S**200** is negative, since it means that the trim-up operation is not needed, the program proceeds to S**202**, in which the trim-up operation is stopped, more precisely, not conducted. When the result in S**200** is affirmative, i.e., when the change amount DTH is equal to or greater than the predetermined value DTHb and the transmission **74** is changed to the first speed, the program proceeds to S**204**, in which it is determined based on the engine speed NE whether it is immediately before the acceleration in the first speed is completed and the transmission **74** is changed back from the first speed to the second speed.

Specifically, the engine speed NE is compared to a trim-up prescribed speed NEc. When the engine speed NE is equal to or greater than the prescribed speed NEc, it is determined to be immediately before the acceleration in the first speed is completed and the gear position is changed back from the first speed to the second speed. The prescribed speed NEc is set as a criterion (e.g., 5000 rpm) for determining whether it is immediately before the acceleration is completed, more precisely, set lower than the second-speed change prescribed speed NEa which is the threshold value used when the gear position is changed back from the first speed to the second speed.

When the result in S**204** is negative, since it is not the time to start the trim-up operation, the program proceeds to S**202**, whereafter the program is terminated without conducting the trim-up operation. When the result in S**204** is affirmative, the program proceeds to S**206**, in which it is determined whether the trim angle θ is less than the maximum trim angle (the maximum value in the possible trim angle range which can be reached through the trim-up operation by the trim unit **24**, e.g., 10 degrees).

When the result in S**206** is negative, since it is impossible to further trim up the outboard motor **10**, the program proceeds to S**202**, in which the trim-up operation is stopped or not conducted. On the other hand, when the result in S**206** is affirmative, the program proceeds to S**208**, in which the trim unit **24** is operated to start and conduct the trim-up operation. Thus, the trim-up operation is started before the acceleration is completed and the transmission **74** is changed back from the first speed to the second speed, thereby increasing the boat speed.

In the next program loop, when the result in S**200** is negative, i.e., when the gear position is changed from the first speed to the second speed in S**134** and the bit of the trim-up permitting flag is reset to 0 in S**140**, the program proceeds to S**202**, in which the trim-up operation is stopped or not conducted.

In S**200**, it is also determined whether the signal indicating the trim-up/down command or the like is outputted upon the manipulation of the trim switch **160** by the operator. When the signal is outputted, the trim unit **24** is operated in response to the outputted signal regardless of the bit of the trim-up permitting flag. Owing to this configuration, the operator can operate the trim unit **24** by manipulating the trim switch **160**, thereby enabling to regulate the trim angle θ at any time.

Returning to the explanation on the FIG. **7** flowchart, the program proceeds to S**14**, in which it is determined whether low-speed cruise control (trolling control) for controlling the propeller rotational speed to make the boat **1** cruise at relatively low speed, is in execution. Specifically, when the propeller rotational speed increase/decrease command is outputted from the trolling switch **162**, the low-speed cruise control is determined to be in execution.

When the result in S**14** is negative, the remaining steps are skipped and when the result is affirmative, the program proceeds to S**16**, in which it is determined whether the rotational speed of the propeller **70** should be increased.

FIG. **10** is a subroutine flowchart showing the operation of the propeller rotational speed increase determination. First, in S**300**, it is determined whether the propeller rotational speed increase command is outputted from the trolling switch **162**, i.e., whether the increase in the propeller rotational speed is instructed by the operator. When the result in S**300** is negative, the remaining steps are skipped and when the result is affirmative, the program proceeds to S**302**, in which it is determined whether the bit of a minimum engine speed flag (described later) is 0.

Since the initial value of this flag is 0, the result in S**302** in the first program loop is generally affirmative and the program proceeds to S**304**, in which the engine speed NE is increased. Specifically, a first prescribed value NEd**1** (e.g., 50 rpm) is added to the present desired engine speed NEd and the obtained sum is set as a new desired engine speed NEd.

Consequently, the intake air amount of the engine **30** is regulated (i.e., increased) through the throttle valve **38** and secondary air amount regulation valve **44** so that the engine speed NE is converged to the newly-set desired engine speed NEd. Therefore, the engine speed NE is increased and the propeller rotational speed is also increased accordingly (in other words, the boat speed is slightly accelerated).

When the result in S**302** is negative, the program proceeds to S**306** onward, which process will be explained later.

In FIG. **7**, the program proceeds to S**18**, in which it is determined whether the rotational speed of the propeller **70** should be decreased.

FIG. **11** is a subroutine flowchart showing the operation of the propeller rotational speed decrease determination. First, in S**400**, it is determined whether the propeller rotational speed decrease command is outputted from the trolling switch **162**, i.e., whether the decrease in the propeller rotational speed is instructed by the operator. When the result in S**400** is affirmative, the program proceeds to S**402**, in which it is determined whether the present engine speed NE is greater than a predetermined speed NE**1**. The predetermined speed NE**1** is set to a value lower than an idle speed NEi (e.g., 800 rpm) of the engine **30**, which value is also the minimum value (e.g., 700 rpm) in a range that can prevent the engine from stalling.

When the result in S**402** is affirmative, the program proceeds to S**404**, in which the engine speed NE is decreased. Specifically, a second prescribed value NEd**2** (e.g., 50 rpm) is subtracted from the present desired engine speed NEd and the obtained difference is set as a new desired engine speed NEd. Consequently, the intake air amount of the engine **30** is regulated (i.e., decreased) through the throttle valve **38** and secondary air amount regulation valve **44**. Therefore, the engine speed NE is decreased and the propeller rotational speed is also decreased accordingly (in other words, the boat speed is slightly decelerated).

On the other hand, when the result in S**402** is negative, i.e., when the decrease command is again outputted when and after the engine speed NE has been decreased to the predetermined speed NE**1**, the program proceeds to S**406**, in which the bit of the minimum engine speed flag is set to 1 and the program is terminated. This flag is set to 1 when the decrease command is outputted at the time the engine speed NE is at or below, more exactly at the predetermined speed NE**1**, and otherwise, reset to 0.

When the result in S**400** is negative, the steps of S**402** to S**406** are skipped.

In FIG. **7**, the program proceeds to S**20**, in which, based on the engine speed NE and propeller rotational speed decrease command, it is determined whether the gear position (speed) should be changed.

FIG. **12** is a subroutine flowchart showing the operation of the speed change determination. As shown in FIG. **12**, in S**500**, it is determined whether the bit of the minimum engine speed flag is 1. When the result in S**500** is negative, the program proceeds to S**502**, in which the first and second solenoid valves **116***a*, **116***b* are both made ON so that the second speed is selected (maintained) in the transmission **74**.

When the result in S**500** is affirmative, the program proceeds to S**504**, in which the first and second solenoid valves **116***a*, **116***b* are both made OFF to change the gear position (shift down the gear) of the transmission **74** from the second speed to the first speed. As a result, the propeller rotational speed is further decreased, so that the boat speed is also further decreased.

Then the program proceeds to S**506**, in which the operation of the throttle valve **38** and secondary air amount regulation valve **44** is controlled so that the engine speed NE stays constant, precisely, the engine speed NE of when and after the gear position is changed to the first speed is controlled to be (substantially) equal to the engine speed of before the speed change, whereafter the program is terminated. Thus, since the engine speed NE may be increased due to the change in the gear position to the first speed, the step of S**506** is configured to suppress such the increase.

In the case where, after the gear position is changed from the second speed to the first speed in S**504**, the increase command is outputted from the trolling switch **162**, the result in S**300** is affirmative and that in S**302** is negative, so that the program proceeds to S**306**. In S**306**, the first and second solenoid valves **116***a*, **116***b* are both made ON to change the gear position (shift up the gear) from the first speed to the second speed, thereby increasing the propeller rotational speed and increasing the boat speed accordingly.

Next the program proceeds to S**308**, in which the bit of the minimum engine speed flag is reset to 0 and the program is terminated.

FIG. **13** is a time chart for explaining the operation of the flowcharts of FIGS. **7** and **10** to **12**, i.e., the propeller rotational speed control operation and transmission control during the cruise at low speed.

Under the condition where the transmission **74** is in the second speed and the engine speed NE is at the idle speed NEi, when, at the time t**1**, the propeller rotational speed decrease command is outputted through the down switch of the trolling switch **162** (S**400**), the engine speed NE is decreased by the second prescribed value NEd**2** (S**404**) and the propeller rotational speed is decreased accordingly. The same can be said with respect to the time t**2**.

When, at the time t**3**, the decrease command is again outputted at the time the engine speed NE is decreased to the predetermined speed NE**1** (S**400**, S**402**, S**406**, S**500**), the gear position is changed from the second speed to the first speed (S**504**) and the engine speed NE is controlled to be (substantially) equal to the engine speed of before the speed change (S**506**). The propeller rotational speed is further decreased accordingly.

After that, when, at the time t**4**, the increase command is outputted through the up switch of the trolling switch **162** (S**300**, S**302**), the gear position is changed from the first speed to the second speed (S**306**), so that the propeller rotational speed is increased.

As stated above, the embodiment is configured to have an apparatus and a method for controlling operation of an outboard motor **10** adapted to be mounted on a stern **12***a* of a boat **1** and having an internal combustion engine **30** to power a propeller **70** through a drive shaft (input shaft) **84** and a propeller shaft **72**, a transmission **74** that is installed at a location between the drive shaft **84** and the propeller shaft **72**, the transmission **74** being selectively changeable in gear position to establish speeds including at least a first speed and a second speed and transmitting power of the engine **30** to the propeller **70** with a gear ratio determined by established speed, and a low-speed cruise controller (ECU **140**) adapted to control a rotational speed of the propeller **70** to make the boat **1** cruise at low speed, wherein the low-speed cruise controller includes a propeller rotational speed increase/decrease command outputter (trolling switch **162**) adapted to output an increase command and decrease command of the rotational speed of the propeller **70** in response to manipulation by the operator; and a first-speed changer (ECU **140**, S**18**, S**20**, S**400**, S**402**, S**406**, S**500**, S**504**) adapted to change the gear position from the second speed to the first speed through the transmission **74** when the decrease command is outputted under a condition where the gear position is in the second speed and a speed NE of the engine is equal to or lower than a predetermined speed NE**1**.

With this, it becomes possible to set the predetermined speed NE**1** to a relatively low value but still capable of preventing the engine **30** from stalling, for instance. Consequently, even when the propeller rotational speed decrease command is outputted at the time the engine speed NE is relatively low, since the gear position is changed to the first speed, the propeller rotational speed can be further decreased while the engine **30** avoids stalling, thereby enabling to make the boat **1** cruise at very low speed (i.e., achieving the creeping speed).

In the apparatus and method, the low-speed cruise controller controls the rotational speed of the propeller **70** by regulating an intake air amount of the engine **30** (S**16**, S**18**, S**304**, S**404**). With this, it becomes possible to control the propeller rotational speed through the regulation of the intake air amount until the engine speed NE is decreased to the predetermined speed NE**1**, for instance. Therefore, the propeller rotational speed can be reliably decreased or increased during the low-speed cruise control.

In the apparatus and method, the low-speed cruise controller controls the engine speed NE of when the gear position is changed to the first speed by the first-speed changer to be equal or substantially equal to the engine speed of before the gear position is changed (S**20**, S**506**). Since the engine speed NE is not increased due to the change in the gear position to the first speed, it becomes possible to more reliably decrease the propeller rotational speed when the gear position is changed to the first speed.

In the apparatus and method, the low-speed cruise controller includes:

a second-speed changer (ECU **140**, S**16**, S**306**) adapted to change the gear position from the first speed to the second speed through the transmission **74** when the increase command is outputted after the gear position is changed to the first speed by the first-speed changer. With this, it becomes possible to instantaneously increase the propeller rotational speed.

In the apparatus and method, the propeller rotational speed increase/decrease command outputter comprises a switch (trolling switch **162**) installed to be manually operated by an operator. With this, it becomes possible to easily output the propeller rotational speed increase/decrease command with simple structure.

It should be noted that, although the outboard motor is exemplified above, this invention can be applied to an inboard/outboard motor equipped with a transmission.

It should also be noted that, although the predetermined speed NE**1**, first and second prescribed values NEd**1**, NEd**2**, displacement of the engine **30** and other values are indicated with specific values in the foregoing, they are only examples and not limited thereto.

While the invention has thus been shown and described with reference to specific embodiments, it should be noted that the invention is in no way limited to the details of the described arrangements; changes and modifications may be made without departing from the scope of the appended claims.

What is claimed is:

1. An apparatus for controlling operation of an outboard motor configured to be mounted on a stern of a boat and having an internal combustion engine to power a propeller through a drive shaft and a propeller shaft, a transmission that is installed at a location between the drive shaft and the propeller shaft, the transmission being selectively changeable in gear position to establish speeds including at least a first speed and a second speed, each of the first speed and the second speed being in gear positions, and transmitting power of the engine to the propeller with a gear ratio determined by established speed, and a low-speed cruise controller which controls a rotational speed of the propeller to make the boat cruise at low speed,

wherein the low-speed cruise controller includes:

a propeller rotational speed increase/decrease command outputter which outputs an increase command and decrease command of the rotational speed of the propeller in response to manipulation by the operator;

a first-speed change mechanism which changes the gear position from the second speed to the first speed through the transmission when the decrease command is outputted under a condition where the gear position is in the second speed and a speed of the engine is equal to or lower than a predetermined speed; and

wherein the low-speed cruise controller controls the engine speed of when the gear position is changed to the first speed by the first-speed change mechanism to be equal or substantially equal to the engine speed of before the gear position is changed.

2. The apparatus according to claim **1**, wherein the low-speed cruise controller controls the rotational speed of the propeller by regulating an intake air amount of the engine.

3. The apparatus according to claim **1**, wherein the low-speed cruise controller includes:

a second-speed change mechanism which changes the gear position from the first speed to the second speed through the transmission when the increase command is outputted after the gear position is changed to the first speed by the first-speed change mechanism.

4. The apparatus according to claim **1**, wherein the propeller rotational speed increase/decrease command outputter comprises a switch installed to be manually operated by an operator.

5. The apparatus according to claim **1** wherein the predetermined speed is set to a level lower than an idle speed of the engine.

6. A method for controlling operation of an outboard motor configured to be mounted on a stern of a boat and having an internal combustion engine to power a propeller through a drive shaft and a propeller shaft, and a transmission that is installed at a location between the drive shaft and the propeller shaft, the transmission being selectively changeable in gear position to establish speeds including at least a first speed and a second speed, each of the first speed and the second speed being in gear positions, and transmitting power of the engine to the propeller with a gear ratio determined by established speed, the method executed by a low-speed cruise controller which controls a rotational speed of the propeller to make the boat cruise at low speed and comprising the steps of:

outputting, via a propeller rotational speed increase/decrease command outputter, one of an increase command and a decrease command of the rotational speed of the propeller in response to manipulation by the operator;

changing, via a first-speed change mechanism, the gear position from the second speed to the first speed through the transmission when the decrease command is outputted under a condition where the gear position is in the second speed and a speed of the engine is equal to or lower than a predetermined speed; and

wherein the engine speed is controlled when the gear position is changed to the first speed by the step of changing the gear position to the first speed to be equal or substantially equal to the engine speed of before the gear position is changed.

7. The method according to claim **6**, wherein the rotational speed of the propeller is controlled by regulating an intake air amount of the engine.

8. The method according to claim **6**, further comprising the step of:

changing the gear position from the first speed to the second speed through the transmission when the increase command is outputted after the gear position is changed to the first speed by the step of changing the gear position to the first speed.

9. The method according to claim **6**, wherein the propeller rotational speed increase/decrease command outputter comprises a switch installed to be manually operated by an operator.

10. The method according to claim **6**, wherein the predetermined speed is set to a value lower than an idle speed of the engine.

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